

Promoting Inquiry-Based Learning in Thai Science Education: Enhancing Scientific Literacy and Critical Thinking¹

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Abstract:

Background: Thai science education remains largely lecture-based, emphasizing rote memorization and standardized testing. Such approaches inadequately cultivate scientific literacy and critical thinking—competencies essential for addressing 21st-century challenges such as climate change, healthcare decision-making, and technological innovation. Passive knowledge transmission limits student engagement, constrains higher-order thinking, and weakens learners' ability to apply scientific understanding to real-world contexts. This gap between memorization and authentic inquiry highlights the need for pedagogical transformation toward more student-centered, inquiry-driven learning models.

Purpose: This study investigated the potential of Inquiry-Based Learning (IBL) to enhance scientific literacy and critical thinking in Thai science education. It examined the limitations of traditional methodologies, evaluated IBL implementation through selected case studies, identified barriers to adoption—including teacher preparedness, resource constraints, and curricular rigidity—and proposed recommendations to support systemic reform through policy adjustment, professional development, and curriculum modernization aligned with inquiry principles.

Methods: A comprehensive analytical approach was employed, integrating literature review of constructivist learning theories underpinning IBL, analysis of the Thai National Science Curriculum, and review of science literacy assessment data indicating gaps in comprehension and application. Case studies of successful IBL implementation in Thai institutions were examined to evaluate student motivation, performance, and skill development. The study also assessed teacher preparation programs to identify professional development needs for effective inquiry facilitation. Pedagogical comparisons were conducted between traditional lecture-based instruction and student-centered strategies involving experimentation, collaborative problem-solving, hypothesis formation, and real-world application.

Results: Traditional science instruction demonstrated significant shortcomings, including overemphasis on memorization, limited conceptual understanding, minimal practical application, and insufficient teacher training in inquiry methods. In contrast, IBL case studies revealed improved student motivation, stronger conceptual mastery, enhanced analytical reasoning, and greater collaborative problem-solving skills. STEM models incorporating design thinking and hands-on experimentation further strengthened knowledge retention and contextual understanding. However, implementation challenges included student adjustment

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to active learning, inadequate teacher preparation, limited instructional resources, rigid curricular frameworks, and societal emphasis on standardized testing outcomes.

Conclusions: Inquiry-Based Learning offers an effective pathway for transforming Thai science education by fostering scientific literacy, critical thinking, creativity, and collaboration. Sustainable implementation requires systemic reform, including targeted teacher professional development, curriculum restructuring toward active exploration, improved resource support, and policy frameworks that value critical thinking alongside standardized assessments.

Keywords: Inquiry-based learning, scientific literacy, critical thinking, Thai science education, constructivist pedagogy

1. INTRODUCTION

In the fast-changing field of global education, the need for good scientific literacy is very important, especially in Thailand, where education systems must create critical thinkers who can handle complicated societal issues. The usual rote memorization techniques used in Thai classrooms often do not truly engage students or develop the higher-order thinking skills needed for thriving in the 21st century. Therefore, changing science education to favor inquiry-based learning (IBL) becomes a key solution. IBL pushes students to ask questions, explore, and research, giving them the tools to actively engage with scientific ideas instead of just memorizing them. By creating a setting where students can follow their interests and participate in hands-on activities, schools can improve not just scientific literacy but also the critical thinking skills that are needed for making well-informed choices in a more complicated world.

Inquiry-Based Learning (IBL) is all about getting students involved and actively taking part in their education. This method marks a big change in how teaching is done. IBL pushes students to ask questions, run tests, and join discussions instead of just sitting back and listening to traditional lectures. The curriculum in IBL is set up to support exploration and help develop critical thinking skills, which are key for understanding science. By creating a space where questions fuel learning, teachers can help students feel more responsible for their own education. This approach not only boosts understanding of scientific ideas but also helps students use what they learn in real-life situations, connecting theory to practice. Research shows that using these teaching methods can improve problem-solving skills and lead to a better understanding of scientific processes, showing how important IBL is in today's education (Dana R. Ferris et al., 2013).

In a world that is more complicated and dependent on technology, being able to think critically about scientific ideas is very important. Scientific literacy helps students deal with and understand the huge amount of information out there, allowing them to make smart choices about important topics like climate change, health care, and technology. The use of inquiry-based learning in Thai schools shows that building this literacy not only helps with understanding scientific ideas but also improves problem-solving skills and coding knowledge, as shown in a study of Thai college students (Krittawaya Thongkoo et al., 2024). Additionally, creating a STEM education model that includes design thinking and skills needed for the 21st century shows the need to prepare students to tackle scientific problems in an innovative and team-oriented way (Duongdearn Suwanjinda, 2022). In the end, focusing on scientific literacy in education helps shape a generation of learners who are ready to face future challenges with thoughtfulness and creativity.

Thai science education today mostly uses a traditional lecture method that focuses more on memorizing facts than on critical thinking and real-world applications. This method, while good for basic knowledge, does not prepare students well for today's complex scientific challenges. Recent research shows that changes are needed, with inquiry-based learning



methods shown to improve student understanding and involvement. For example, studies have found that online systems that encourage team inquiry help students enhance their coding skills, problem-solving abilities, and also boost motivation and teamwork among college students (Krittawaya Thongkoo et al., 2024). Moreover, combining inquiry-based and practical learning in teacher training has helped improve research skills in future teachers, suggesting a useful model for broader science education (Duangkamol Chongcharoen et al., 2023). Thus, shifting to an inquiry-focused teaching method is crucial for developing scientific knowledge and critical thinking in upcoming generations of Thai students.

Bringing critical thinking into science education is important for helping students understand scientific ideas better and getting them involved. Learning methods that focus on questions and analysis, which prompt students to think and put together information, can greatly improve important abilities like problem-solving and coding skills (Krittawaya Thongkoo et al., 2024). Such skills are necessary in today's quickly changing tech world, where students face complicated issues. Also, creating STEM teaching models that use critical thinking in a way that respects different cultures helps teachers connect their lessons to skills needed in the 21st century (Duongdearn Suwanjinda, 2022). By including critical thinking in science courses, teachers not only boost scientific knowledge but also prepare students to be active learners who can deal with real-life problems. Overall, encouraging critical thinking in science education both makes academic learning richer and develops informed citizens ready for future difficulties.

The use of Inquiry-Based Learning (IBL) in Thai science education helps students understand science better and grow critical thinking skills that are necessary in a fast-changing world. By moving away from memorizing facts to exploring through questions, students learn to ask questions, make guesses, and do hands-on experiments. This way of learning not only strengthens their understanding of theory but also helps them use scientific methods, improving their problem-solving abilities. Additionally, IBL encourages teaming up and sharing ideas among students, which are important skills in today's connected scientific environment. As students take charge of their own learning, they build a sense of independence and confidence important for continuous learning. Therefore, this move towards IBL, backed by various educational models, connects with the global need to boost scientific knowledge and prepares Thai students with the skills needed to handle complex science problems effectively (National Research Council et al., 2012).

2. THEORETICAL FRAMEWORK OF INQUIRY-BASED LEARNING

Inquiry-based learning (IBL) is based on constructivist ideas, suggesting that knowledge is built actively through experiences instead of just being taken in. This idea shows that students learn better when they can ask questions, explore things, and work on problems that matter to them. In Thai science education, using IBL can greatly improve students' scientific understanding and critical thinking skills. By using teaching methods that focus on students and allow them to create their experiments and find answers on their own, teachers can help students grasp scientific ideas and techniques more deeply. Additionally, this hands-on learning approach helps students feel more responsible and motivated, which is key for lasting success in education. Ultimately, understanding the significance of this idea could change standard teaching methods and promote a more active and adaptable way of teaching science in Thailand (National Research Council et al., 2012).

The growth of Inquiry-Based Learning (IBL) in schooling started in the early 1900s with the progressive education movement. This movement aimed to get students involved in practical, hands-on learning experiences. Leaders like John Dewey stressed that education should engage students actively. They believed education should do more than just pass on



knowledge; it should help develop critical thinking and problem-solving abilities. Today's methods of IBL have included new technology and teamwork strategies, which help students tackle difficult scientific ideas. For example, a recent study found that using a collaborative inquiry-based online system greatly boosted programming skills among Thai college students, showing that IBL can help develop not just thinking skills but also social skills like working together and communicating (Krittawaya Thongkoo et al., 2024). Additionally, other studies have revealed that inquiry-based methods enhance research skills in future teachers, giving them the teaching tools needed to promote scientific understanding in their future classrooms (Duangkamol Chongcharoen et al., 2023). In summary, the history of IBL shows how it can adapt and remain important in today's education, making a strong argument for including it in school programs around the world.

A key part of inquiry-based learning (IBL) is how much it focuses on getting students involved in learning through real questions and problems. This approach puts students at the center and encourages them to actively build their knowledge instead of just receiving information. As students face real-life challenges, they look at information critically, make guesses, and create methods for experiments. This leads to a better understanding and memory of scientific ideas. Moreover, IBL encourages teamwork among students, creating a community where different viewpoints improve problem-solving and critical thinking abilities. By focusing on exploration and inquiry instead of memorizing facts, teachers can create a more engaging and significant learning atmosphere that matches modern educational aims. Using these teaching methods not only improves science education in Thailand but also boosts students' scientific literacy and thinking skills, enabling them to tackle complex global problems in a fast-changing world (Dana R. Ferris et al., 2013).

Inquiry-based learning (IBL) is based on constructivist learning theories, which stress how learners actively build knowledge through their experiences. This is especially important in science education, where grasping complex concepts needs more than just receiving information. IBL encourages teamwork and problem-solving, which fits well with constructivist ideas by allowing students more freedom in their learning, leading to increased involvement and better knowledge retention. For example, a study showed that students using a collaborative inquiry-based online method did better than those in traditional settings, showing improved understanding and motivation (Krittawaya Thongkoo et al., 2024). Additionally, research suggests that these teaching methods help pre-service teachers develop significant skills in research and critical thinking, which supports the effectiveness of constructivist strategies in preparing students for real-life issues (Duangkamol Chongcharoen et al., 2023). Therefore, incorporating IBL in Thai science education not only aligns with constructivist principles but also helps develop the scientific literacy and critical thinking skills that are crucial for today's learners.

Using Inquiry-Based Learning (IBL) in science education leads to more student interest and motivation by creating a more active learning space. Unlike old teaching methods that often make students passive receivers of information, IBL makes students take charge of their learning through solving problems, asking questions, and working together. This independence not only boosts motivation but also helps students understand scientific ideas better since they are involved in their own learning process. Studies show that when students participate in making questions and finding answers, they become more invested in learning, which improves their academic results and understanding of science. Additionally, the teamwork involved in IBL helps develop social skills and a sense of community among students, which further increases their motivation to engage with the content (National Research Council et al., 2012). In conclusion, adopting IBL is a key method for improving both engagement and motivation in science education.



Traditional education systems often have trouble fitting in the methods of Inquiry-Based Learning (IBL), mostly because of fixed practices and slow changes in teaching. School structures often focus on standardized tests and memorization, which go against the exploring and student-focused approach of IBL. Also, teachers, shaped by these systems, may not have the right training and support to use IBL techniques well in their classrooms, causing them to resist changes in teaching methods. The strict curriculum limits teachers' ability to encourage inquiry, as they may feel they must stick closely to required topics, which can limit creativity and critical thinking in students (Samuel Kai Wah Chu et al., 2018). As a result, the gap between the aim of boosting scientific understanding and critical thinking through IBL and the facts of traditional teaching methods creates a significant challenge. Tackling these issues needs a system-wide change that appreciates and supports creative teaching approaches.

3. CURRENT STATE OF SCIENCE EDUCATION IN THAILAND

The changing scene of science teaching in Thailand shows a strong need for changes in teaching methods to improve students' science understanding and thinking skills. Traditionally, teaching has mostly been lecture-based, but now there is a push for new ways of teaching like inquiry-based and real-world learning. Recent research shows that these techniques are good at building research abilities in future teachers, indicating that changes could notably enhance learning results (Duangkamol Chongcharoen et al., 2023). Also, creating STEM education with strategies that relate to real-life and 21st-century skills indicates a move toward more hands-on and meaningful science education (Duongdearn Suwanjinda, 2022). Thus, while there are still issues with the curriculum and teacher preparation, the current focus on inquiry-based teaching offers a hopeful pathway for improving science education in Thailand. By creating settings that support exploration and critical thinking, Thai students can more effectively handle the challenges of modern science and become knowledgeable citizens.

In the past years, the Thai National Curriculum for Science has made big changes to match global education standards, creating a more hands-on learning experience. A key aspect of this curriculum is the focus on critical thinking and scientific understanding, which are important skills for dealing with today's issues. By including practical experiments, group projects, and solving real-life problems, the curriculum helps students to actively engage with science topics instead of just receiving information. This teaching approach seeks to build a group of learners who not only know facts but can also use their knowledge in different situations. However, there are still issues with putting these changes into practice, especially in schools that don't have enough resources, where access to materials and trained teachers is hard to find (National Research Council et al., 2012). In the end, fixing these gaps is essential for achieving the full benefits of the updated curriculum and improving education in Thailand.

The checking of science learning levels in Thai students shows big gaps that point to a need for changes in science teaching. Current tests show that a lot of students have trouble not just with basic science ideas but also with using these ideas in real life. Weak teaching methods, which often focus on memorizing facts instead of learning through questions, make these issues worse, preventing students from thinking critically about science topics. This problem is made worse by social and cultural influences that can sometimes lower the value of science inquiry, resulting in less interest in studying science. By using more inquiry-based teaching methods, teachers can create a setting that encourages better understanding and excitement for science, which can improve science learning levels among students. Fixing these gaps is important for getting Thai students ready to deal with a world that is more complex and reliant on science, meaning that serious changes in education are needed now (Maizatulliza Muhammad et al., 2020).



The limits of current teaching methods, mainly those based on lectures, stop the growth of scientific understanding and critical thinking in students. Traditional ways focus on memorizing facts and passive learning, which do not help students get involved in science or make them question basic ideas. Consequently, students often find it hard to use what they learn in real life, which makes it difficult for them to think critically about information. Also, these old practices do not meet different learning styles and do not promote teamwork or inquiry, both of which are vital for a society that understands science well. Supporters of inquiry-based learning say that changes in education need to fix these issues by using more interactive, student-focused approaches that spark curiosity and critical thinking skills. Such improvements could help students become active in their learning, which would improve their ability to work through and impact a complex scientific world (Mei-Hung Chiu, 2016).

The effectiveness of inquiry-based learning in the Thai science curriculum greatly depends on how well teachers are prepared, a factor that is often not sufficiently covered in current professional development programs. Recent research shows that many teachers do not have the training or support needed to apply inquiry-based teaching methods effectively. This shortfall not only affects their teaching quality but also reduces student engagement and understanding in science subjects. This situation points to a pressing need for focused professional development plans that provide teachers with the tools, resources, and teaching methods essential for promoting inquiry in their classrooms. Additionally, creating a strong support system for teachers can encourage ongoing learning and teamwork among educators, which can boost their confidence and skills in inquiry-based teaching approaches (National Research Council et al., 2012). By committing to comprehensive professional development programs, stakeholders can greatly enhance educational results and help develop a group of students skilled in critical thinking and scientific understanding.

Using Inquiry-Based Learning (IBL) effectively in Thai schools has shown good progress in improving students' scientific literacy and critical thinking. For example, a learning framework based on constructivism has been found to boost student involvement and comprehension, as shown by a research and development method that gave student teachers clear and useful resources (Pol Luangrangsee et al., 2024). Also, the use of collaborative online inquiry systems led to better coding skills and problem-solving among students, which shows IBL can adapt to various subjects, such as science education (Krittawaya Thongkoo et al., 2024). These examples not only show the useful effects of IBL but also highlight the need for teacher training and resource development for long-term success. In the end, adding these methods to the Thai education system will be key to changing old teaching methods and developing a new generation of learners with important critical thinking skills.

4. ENHANCING SCIENTIFIC LITERACY THROUGH INQUIRY-BASED LEARNING

Using inquiry-based learning methods in science classes can greatly improve how well students understand science. This style focuses on students learning through exploration, experiments, and critical thinking, which meets modern education needs. Research shows that these methods help students grasp difficult topics and develop important skills like problem-solving and teamwork. For example, a study found that students who use collaborative inquiry-based online systems do better than their peers in both understanding concepts and coding skills, as seen with Thai undergraduates (Krittawaya Thongkoo et al., 2024). Also, combining methods that encourage design thinking and real-world relevance can make inquiry-based learning even more effective, as seen in a new STEM education model created for Thai science teachers (Duongdearn Suwanjinda, 2022). In the end, boosting scientific literacy through



inquiry-based learning helps students engage with and impact the fast-changing scientific world.

Understanding scientific literacy means not just knowing scientific ideas but also being able to think critically about information. This idea of scientific literacy is very important for creating informed citizens who can deal with difficult societal issues like climate change, public health problems, and new technologies. It requires skills in scientific methods, the value of using evidence for reasoning, and the ability to analyze how scientific results affect social values and ethics. Therefore, improving scientific literacy in the Thai education system is a necessary goal, especially as the world becomes more connected. Inquiry-based learning is a good teaching method to boost this literacy, allowing students to actively participate in science while developing critical thinking skills that help them question assumptions and make well-informed decisions. Combining these teaching methods can greatly improve individual skills and strengthen society as a whole (National Research Council et al., 2012).

Inquiry-Based Learning (IBL) is a teaching method that greatly improves how students understand science by encouraging them to be active and think critically. It lets students ask questions, set up experiments, and review data, helping them feel more in charge of their learning, which results in better understanding and remembering of science ideas. This approach helps students link what they learn in theory to real-life situations, providing a deeper and more relevant understanding of science than traditional teaching often does. Additionally, IBL builds teamwork skills as students collaborate in groups, sharing ideas and creating a learning community. This teamwork not only reflects how scientific research is done but also boosts the communication skills needed for being scientifically literate. Thus, IBL not only helps students gain knowledge but also prepares them with critical thinking skills for tackling tough scientific problems (National Research Council et al., 2012).

Getting students involved with hands-on experiments and real-life applications changes how science is taught, helping them understand and remember better. When students take part in experiments, they gain practical skills and a clearer grasp of scientific ideas that can seem unclear when only read in books. This type of learning encourages critical thinking, as students need to make guesses, look at results, and change their methods based on what happens during their experiments. Also, linking scientific ideas to everyday situations makes complicated theories easier to understand and shows how science is part of daily life, which can inspire students to learn more. Research shows that these interactive methods significantly boost student involvement and success, especially in weaker educational systems like Thailand, where inquiry-based learning is just starting to grow. In conclusion, combining hands-on activities with real-world applications can build a strong base for developing scientific knowledge and critical thinking (National Research Council et al., 2012).

Good assessment strategies are really important for improving scientific understanding, especially in learning that is based on inquiry. There are different methods, like formative and summative assessments, that can show how well students understand and use scientific ideas. For example, using real-life assessments, like projects or solving real-world problems, helps teachers see how students think critically and reason in a meaningful way. Studies from the Philippines have indicated that adding different learning activities not only builds leadership skills but also improves scientific understanding, showing how good assessment connects with inquiry-based learning (B. Cavas, 2024). Also, using tools like rubrics can make expectations clear and give detailed feedback on how students are doing, which helps them get better over time. In the end, using a variety of assessment methods can lead to a deeper understanding of scientific concepts, giving students the skills they need to think critically about scientific issues, as shown in the increasing research on this subject (Bülent Çavaş, 2024).



Inquiry-based learning (IBL) activities can boost scientific literacy by building skills like critical thinking, problem-solving, and communication. For example, when students participate in hands-on experiments where they come up with their own hypotheses, they can explore scientific ideas on their own, which helps them understand the subject better. Also, write-to-learn (WTL) tasks are a good IBL method because they let students express their thoughts and think about their learning. As shown in (Ayuni Ratnayake et al., 2023), when students pick a topic, do research, and think about what they learned, they develop metacognitive skills that improve their confidence in scientific writing. Additionally, the solid administrative support for inquiry-based methods mentioned in (Jonalyn S. Guerrero et al., 2023) highlights the need for an environment that supports these activities. Together, these IBL strategies not only enhance scientific literacy but also encourage a lasting interest in scientific inquiry, which is vital for developing future scientists.

5. FOSTERING CRITICAL THINKING SKILLS IN SCIENCE EDUCATION

The growth of science education needs to focus on developing critical thinking skills, which are important in a complicated world. Models like the InThai21DT framework help connect old teaching methods with new teaching styles, showing that this can lead to better student engagement and understanding. Using inquiry-based learning methods, this approach supports research that highlights the importance of teamwork, leading to deeper understanding and improved problem-solving skills (Krittawaya Thongkoo et al., 2024). Also, adding 21st-century skills, design thinking, and local cultural factors into the STEM curriculum makes science education more relevant and useful, creating a more engaging and effective learning experience. These methods not only help students face real-world issues but also encourage a lasting interest in exploration and reflection, building the critical thinking skills needed for future accomplishments in science and other fields (Duongdearn Suwanjinda, 2022).

In education, critical thinking is not just a nice skill to have; it is a key part of scientific literacy. Critical thinking allows students to assess information, identify biases, and combine different viewpoints, leading to a better grasp of scientific ideas and the surrounding world. This idea is supported by the recent move toward inquiry-based learning methods, especially in Thai science education, where students are motivated to ask questions and investigate their learning spaces. These teaching methods not only enhance factual knowledge but also improve problem-solving skills and coding abilities, as shown in the collaborative inquiry-based system used in Thai universities (Krittawaya Thongkoo et al., 2024). Moreover, instruction models that use real-world situations, like the InThai21DT model, show how critical thinking helps develop important 21st-century skills, such as creativity and teamwork (Duongdearn Suwanjinda, 2022). These points highlight the importance of developing critical thinking skills in educational environments to better equip students for complex, real-world situations.

Inquiry is a key part to develop thinking skills that are critical, creating a learning space where students are not just getting information but are involved in their own learning. When students learn through inquiry, they improve their skills to question what they believe, look at problems, and find solutions. This is shown in studies of current teaching methods. For example, using a teamwork inquiry-based online system has been proven to improve problem-solving skills and coding among college students, showing how inquiry helps higher-level thinking (Krittawaya Thongkoo et al., 2024). Also, including STEM teaching models that focus on inquiry in Thailand has been connected to better preparation for both teachers and students to tackle complicated issues while using design thinking (Duongdearn Suwanjinda, 2022). This focus on both students and teachers shows how inquiry can improve critical thinking skills in education, especially in science learning.



To help students improve their critical thinking and problem-solving skills, it is important to use various methods that focus on involvement and teamwork. One way to do this is by adding real-life problems into lessons, which helps students see scientific ideas in context and pushes them to come up with new answers. By presenting learners with tough, open-ended questions and fostering group talks, teachers can create a space where critical thinking is not only encouraged but necessary for achievement. Also, using reflective activities like journaling or peer reviews helps students express their thinking and look at different views, building an awareness of their own thought processes that is important for scientific research. Furthermore, teacher training should focus on teaching techniques that support this type of learning, ensuring that educators can help students navigate the complexities of problem-solving and analysis needed for scientific understanding (OECD, 2019).

Working together in learning environments helps not just in gaining knowledge but also in building critical thinking skills that are necessary for understanding complex scientific ideas. When students collaborate, they share their thoughts, challenge each other's reasoning, and combine different points of view, which leads to discussions that deepen their comprehension. This interaction fosters a curiosity that is crucial for critical analysis, as students practice evaluating evidence, checking the strength of arguments, and making informed decisions based on group talks. Additionally, the responsibility in teamwork drives individuals to prepare more thoroughly, aiming to make a valuable contribution to the group's results. Therefore, using collaborative learning methods in Thai science education not only improves scientific understanding but also develops a more thoughtful and analytical student body that can use critical thinking in practical situations (Samuel Kai Wah Chu et al., 2018). By focusing on these teaching methods, teachers can greatly improve the quality of science education.

Bringing in critical thinking tests into inquiry-based learning (IBL) settings is very important for building scientific knowledge in students. To really evaluate and solve tough problems, students need to do activities that push their thinking and analysis skills, which helps them understand the subject better. Using a teamwork-focused online inquiry setup has shown good outcomes in improving programming skills, showing that similar approaches could work well in science education. A recent study found that the group that participated in this format not only did better than others in coding skills but also showed increased involvement and teamwork abilities (Krittawaya Thongkoo et al., 2024). These qualities are crucial for scientific inquiry, where working together and clear communication are key. Moreover, creating a specific STEM education model highlights the importance of including local context and modern skills, indicating that tests should match these ever-changing and situational learning experiences (Duongdearn Suwanjinda, 2022). In the end, good assessment techniques can turn IBL into a strong way to develop critical thinking in Thai science education.

6. CONCLUSION

Based on the evidence shown, it is clear that adding inquiry-based learning methods in Thai science education is important for developing scientific skills and critical thinking in students. The current system, which focuses on memorizing facts and standardized tests, limits creativity and problem-solving skills, which harms the ability to develop a knowledgeable population in science. By using inquiry-based methods, teachers can create active learning settings where students can explore scientific ideas, promoting curiosity and investigation. This change in teaching style matches worldwide education trends that emphasize critical thinking and applying knowledge practically, helping students tackle complicated scientific issues. In the end, shifting to inquiry-based learning in Thailand can greatly strengthen the skills of future generations, helping them succeed in a more complex and science-oriented world (National Research Council et al., 2012).



Inquiry-based learning is needed in Thai science education because it helps build scientific literacy and critical thinking, which are important skills in today's quickly changing knowledge economy. By having students actively explore, this method not only improves their grasp of scientific ideas but also encourages a habit of questioning and discovery. This change in teaching addresses the flaws of traditional memorization techniques, which often do not prepare students to use knowledge in real life. Additionally, inquiry-based learning promotes teamwork in solving problems and boosts creativity, both of which are necessary for innovative thinking. For these reasons, those involved in education must focus on training teachers to use inquiry-based methods, making sure they can create such learning environments. Ultimately, advancing inquiry-based learning in Thai science education is a crucial step to improve education outcomes and get students ready for future challenges in a more complicated world (National Research Council et al., 2012).

The integration of inquiry-based learning into Thai science education needs big changes in policy and curriculum to build scientific literacy and critical thinking in students. Current education systems often ignore the active aspect of scientific inquiry, as shown by research indicating that students have a hard time grasping the nature of scientific inquiry (NOSI) because of curriculum limitations (Sasivimol Premthaisong et al., 2022). To fix this issue, policymakers should push for a curriculum that focuses on practical, inquiry-focused activities while using digital tools to effectively engage students. Moreover, creating a STEM education model that fits the Thai context, like the InThai21DT model—which includes literacy skills, 21st-century skills, and design thinking—can provide a clear and thorough method for teaching (Duongdearn Suwanjinda, 2022). By changing policies to highlight these factors, schools can greatly improve students' abilities to think critically and use scientific ideas well.

Good teacher training and ongoing professional development are very important for promoting inquiry-based learning, especially in Thai science education. Programs need to focus on hands-on, practical methods that help teachers get students involved in research activities, as shown by the big improvements in skills among pre-service teachers when they learn through inquiry and situated learning methods (Duangkamol Chongcharoen et al., 2023). Also, integrating STEM education training for science teachers is necessary; this training should provide not just knowledge but also teaching methods that fit with 21st-century skills and critical thinking (Duongdearn Suwanjinda, 2022). In addition, ongoing support—like mentorship and teamwork among teachers—can help keep teachers committed to new methods. By putting money into thorough training that emphasizes inquiry and critical thinking, schools can create a more active and responsive learning space, which will improve scientific literacy for students in Thailand.

Expanding inquiry-based learning (IBL) in science education needs to look at several important areas mentioned in recent studies. Future research should focus on using digital technologies as helpful tools in IBL settings because they can improve students' grasp of difficult scientific ideas. For example, a collaborative online inquiry-based system used in Thailand showed good progress in programming and problem-solving skills for college students, indicating that technology can boost interest and motivation in science learning (Krittawaya Thongkoo et al., 2024). Also, it is important to dig deeper into the Nature of Scientific Inquiry (NOSI) in elementary education since research shows that many students do not understand the various parts of scientific inquiry (Sasivimol Premthaisong et al., 2022). Detailed studies on teaching methods that include these aspects could result in better IBL practices and help encourage critical thinking and scientific knowledge among different student groups.

In summary, using Inquiry-Based Learning (IBL) in Thailand's education system is not just helpful, it is necessary for preparing a generation of citizens who understand science and



can deal with tough global issues. The common rote learning methods found in many Thai schools limit critical thinking and creativity, which are very important in today's world. IBL, on the other hand, engages students in hands-on activities and problem-solving, fostering curiosity and involvement, and helping them relate what they learn to real-life situations. Additionally, applying IBL can help reduce the gaps in educational results among various socio-economic groups in Thailand, supporting fairness and inclusion in science education. In the end, adopting IBL not just allows students to be active and informed in their communities but also greatly aids national growth, making Thailand more competitive in the global knowledge market.

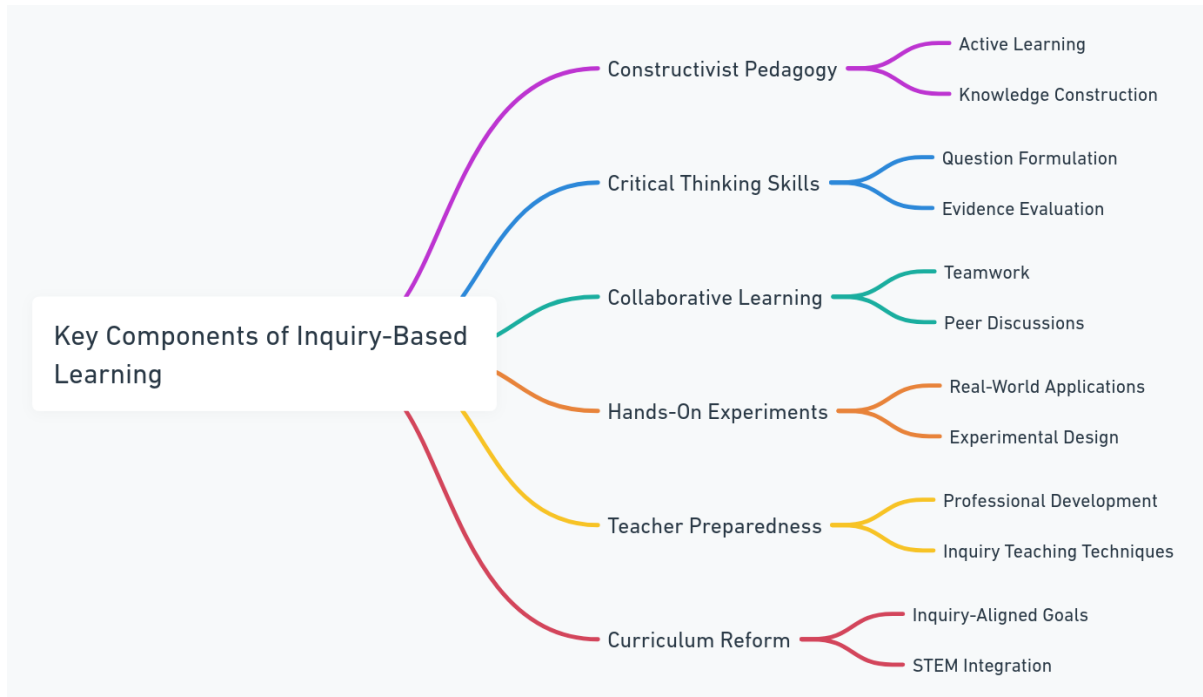


Figure 1: Key Components of Inquiry-Based Learning

Originality & Body of Knowledge

Originality: This paper makes a significant contribution to the field of science education by focusing on the transformative potential of Inquiry-Based Learning (IBL) in the context of Thai science education. While IBL has been widely discussed in global educational research, this study provides a localized analysis tailored to Thailand's unique educational challenges, such as the prevalence of rote memorization and standardized testing. The paper offers fresh insights into how IBL can address these issues by fostering scientific literacy and critical thinking skills among Thai students. By integrating case studies from Thai educational institutions, the research demonstrates the practical efficacy of IBL in enhancing student motivation, understanding, and performance. Additionally, the paper highlights the importance of teacher preparedness and systemic curriculum reforms, offering actionable recommendations for policymakers and educators. This study not only advocates for a paradigm shift in Thai science education but also provides a replicable framework for other countries facing similar educational challenges.

Body of Knowledge: This study builds on existing literature by integrating global perspectives on IBL with a localized analysis of Thai science education. It draws on foundational works such as the National Research Council's Framework for K-12 Science Education (2012), which emphasizes the importance of inquiry-based approaches in developing scientific literacy and critical thinking. The paper also aligns with contemporary research on the role of IBL in fostering 21st-century skills, such as creativity, teamwork, and problem-solving, as highlighted by scholars



like Samuel Kai Wah Chu and Mei-Hung Chiu. By examining the current limitations of Thai science education and proposing IBL as a solution, the study adds to the body of knowledge on how inquiry-based methods can be adapted to meet the specific needs of developing educational systems. The findings underscore the importance of teacher training, collaborative learning, and the integration of real-world applications in science education, offering a comprehensive approach to enhancing both academic outcomes and student engagement. This research not only contributes to the academic discourse on IBL but also provides practical recommendations for improving science education in Thailand and beyond.

Declarations

Conflict of interest: The authors declare no conflicts of interest.

Ethical treatment of experimental subjects (animals & human): The research was conducted in compliance with the principles of the Helsinki Declaration regarding human subjects, so formal ethical approval was not required.

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